ASSESSMENT OF BARRIERS TO USING DEPTH OF ANESTHESIA MONITORING

by

Sarah Ashley Zakula

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As members of the DNP Project Committee, we certify that we have read the DNP project prepared by *Sarah Ashley Zakula*, titled *Assessment of Barriers to using Depth of Anesthesia Monitoring* and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

Mary Davis Date: April 19, 2019
Mary Davis, PhD, RN, CPHQ

Kathleen A Piotrowski Date: April 19, 2019
Kathleen A. Piotrowski, DNP, CRNA

Kristie Hoch Date: April 19, 2019
Kristie Hoch, DNP, CRNA, MS, RRT

Final approval and acceptance of this DNP project is contingent upon the candidate's submission of the final copies of the DNP project to the Graduate College.

I hereby certify that I have read this DNP project prepared under my direction and recommend that it be accepted as fulfilling the DNP project requirement.

Mary Davis Date: April 19, 2019
DNP Project Director: *Mary Davis, PhD, RN, CPHQ*

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ABSTRACT

Background: Depth of Anesthesia monitoring is an available technology used to determine the depth of a patient's anesthetic by analyzing the electroencephalogram readings of the anesthetized patient. This technology has been available since the 1990s, yet it is not commonly used during the average anesthetic plan.

Objective: To determine what barriers prevent anesthesia providers from choosing to use a depth of anesthesia monitor as a regular part of their practice, to assess the needs of the providers involved, and encourage and increase the use of depth of anesthesia monitoring when appropriate.

Design: Using descriptive methodology, providers were administered a pretest, self-paced educational module, and posttest that examined their current practice regarding the use of depth of anesthesia monitoring and their willingness to change.

Setting: A 487-bed Level I trauma center in Southern Arizona.

Participants: Seven Certified Registered Nurse Anesthetists (CRNAs)

Measurements: Responses to pretest and posttest questions, and comparisons between the two surveys based on provider.

Results: Most providers have never used a depth of anesthesia monitor at this facility, though they would be willing to try using them. Providers had a strong knowledge of when depth of anesthesia monitoring is recommended, but reported they prefer a different approach to monitoring anesthetic depth.

Conclusion: Providers reported that an in-service on the monitors would enhance their ability to use the monitors and give them confidence in interpretation of the monitor's values.

INTRODUCTION

Intraoperative awareness (IOA) is the explicit recall of events that happened while a patient received a general anesthetic (Brown, Solt, Purdon, & Johnson-Akeju, 2015). Though IOA is rare, 0.5% as reported by Messina et al. (2016), it is a cause for concern because of its significance—the potential for negative physical and psychological distress. In some patients, the ability to recall surgical events has led to posttraumatic stress disorder (Mashour & Pryor, 2015). Although rare, its effects are severe, making it a phenomenon worth studying and preventing. Depth of anesthesia (DoA) monitoring is a method used to prevent IOA. Not all facilities have depth of anesthesia monitors, because DoA monitoring is not a standard of care required by the American Association of Nurse Anesthetists (AANA) or the American Society of Anesthesiologists (ASA). In hospitals that do have DoA monitors, they are not regularly used (Gelfand, Gabriel, Gimlich, Beutler, & Urman, 2017). It is unclear why providers choose not to use DoA monitors in their practice, but several possibilities will be explored through the course of this project.

Background Knowledge

A pioneer in anesthesia, Dr. John Snow, known for introducing chloroform as an anesthetic agent, and for his work in epidemiology, began experimenting with general anesthesia in the nineteenth century. Dr. Snow first described anesthesia as being achieved in "stages," and his work was later expanded on by Dr. Arthur Guedel (Ball & Westhorpe, 2010). In the early years of anesthesia, one of the techniques used to render patients' unconscious was the open-drop method (Metzenbaum, 1906). This method utilized a mask covered with six to eight layers of gauze and held three or four inches above the patient's face (Metzenbaum, 1906). The

anesthesia provider then administered the anesthetic agent, chloroform or ether, via a dropper as the patient breathed deeply and began counting from zero (Metzenbaum, 1906). As the patient inhaled, vapors of the anesthetic mixed with air, thereby delivering a partially warmed gas diluted with air to the patient's lungs (Metzenbaum, 1906). As the provider administered the agent via dropper, he or she also lowered the mask until it almost rested against the patient's face (Metzenbaum, 1906). The patient then became relaxed and unconscious, and the surgeon could begin the necessary procedure. To keep the patient anesthetized, the provider needed to continue administering agent via dropper, but as the patient saturated with anesthetic, a lesser amount was needed to maintain the patient in this state (Metzenbaum, 1906). Metzenbaum compared this method to another pioneer method that included partial asphyxiation (1906). With this method, no fresh air was allowed into the system, and the result was a patient who went to sleep holding their breath, choking, and struggling (Metzenbaum, 1906). The open-drop method was a significant improvement, and produced a patient that appeared asleep and comfortable, while remaining pink and warm during the induction of anesthesia (Metzenbaum, 1906).

The next major advancement in anesthesia was the development of muscle relaxants, or paralytics, which render the patient's skeletal muscles immobile (Ball & Westhorpe, 2010). It was first popular to anesthetize patients with light anesthesia and profound muscle relaxation, known as the Liverpool Technique (Ball & Westhorpe, 2010). This technique did not stay in fashion long, however, as patients complained of being conscious and frightened during their final moments of surgery. The first case of awareness, documented in 1950, recounts a patient remembering waking up during surgery and experiencing overwhelming pain (Ball & Westhorpe, 2010). This fueled the concern that patients would remember the events of their

procedures. The first study published regarding awareness shocked the anesthesia community by reporting that awareness is present in 2.78% of anesthetized patients (Hutchinson, 1961).

Despite these fears, it took until the 1990s for technology to become available that could assess the depth of a patient's anesthesia. Systems such as the Bispectral index (BIS), Narcotrend index, and Patient State Index (SEDLine) have entered the market with the analysis of electroencephalogram (EEG) activity to determine brain function while under general anesthesia. Prior to the invention of these monitors, anesthesia providers relied on physical symptoms to identify an insufficient level of anesthesia. These symptoms occur as a result of painful stimuli or as a response to stress and are identified as increased heart rate, increased blood pressure, increased respiratory rate, or patient movement (Musizza & Ribaric, 2010). All monitors used for depth of anesthesia analysis contain constructed abstract quantities that are not linked to any physiological parameters and have an inherent time delay while data is gathered and processed through the algorithm (Musizza & Ribaric, 2010). Typically, the monitor analyzes the EEG waveforms using a proprietary algorithm and produces a dimensionless number that correlates to the level of the patient's anesthetic depth (Smith, Skues, & Philip, 2015).

The Bispectral index (BIS) monitor, introduced in 1992, uses a single channel EEG which is measured from the sensor strip applied to the patient's forehead. Analysis of the EEG signal is analyzed and processed using an algorithm for artifact detection and two different types of burst suppression are applied. The variables of beta wave ratio, burst suppression ratio, and bispectral ratio are used in an algorithm to produce the BIS index value. The value is dimensionless and ranges from 0-100. The monitor can detect electromyogram (EMG) activity—indicating movement of the facial muscles. This information does not add to the

development of the BIS index value but instead provides a secondary monitor for the clinician, knowing that movement of the facial muscles indicates a more conscious patient who may be grimacing in response to stress of surgery or pain (Musizza & Ribaric, 2010).

The Narcotrend monitor entered the market in 2000. It can classify anesthesia into up to fifteen different stages, depending on the version of the software available. The Narcotrend also displays an index value of 0-100 for comparison with the more widely known BIS monitor. The Narcotrend index records a one-channel EEG waveform from a three-electrode sensor placed on the patient's forehead. The data gathered from the EEG undergoes artifact detection and removal algorithms. The monitor uses relative brain waves, burst suppression analysis, and frequency domain analysis to calculate the Narcotrend index value (Musizza & Ribaric, 2010).

The Patient State Analyzer (PSA) was introduced in 2001. After being sold to another company in 2005, the PSA is now called the SEDline monitor, and the value produced by this monitor is the Patient State Index (PSI). Unlike other depth of anesthesia monitors, the SEDline uses the analysis of four EEG waveforms to develop its 0-100 PSI value. The signals obtained from the monitor are pre-processed and subjected to an artifact removal algorithm. The frequency of multiple EEG bands is determined, as well as a total EEG frequency band. The SEDline uses information obtained between different brain regions to quantify and develop the PSI number. In addition, the SEDline monitor analyzes burst suppression and arousal detection, which are used to modulate the PSI value in the event that signal quality is questioned. Before the PSI value is displayed on the monitor, the PSI is post-processed with an averaging algorithm, which provides a more stable output (Musizza & Ribaric, 2010).

When using a DoA monitor during general anesthesia, a value of 40 to 60 is the targeted goal for proper anesthesia of the brain, whether this is the BIS value, Narcotrend index, or PSI (Smith, Skues, & Philip, 2015). A value of 100 indicates that the patient is completely awake (Brown et al., 2015). Keeping the patient in the 40 to 60 range ensures that neurologically, the patient is receiving an adequate amount of anesthetic which should prevent the patient from experiencing IOA with recall. The ability to titrate anesthetics to a set goal is critical when the patient is receiving muscle relaxants, and unable to move or physically respond to surgical stimulation (Brown et al., 2015).

There is a guideline supported by the former National Guidelines Clearinghouse that recommends which types of patients, surgeries, and anesthetic approaches should use a DoA monitor (National Institute for Health and Care Excellence [NICE], 2012). The recommendations are as follows: patients who are at higher risk of the adverse outcomes of unintended awareness and excessively deep anesthesia should receive DoA monitoring. Types of patients who are at higher risk include those who regularly use large amounts of opiates or alcohol, patients with airway problems, and patients with previous history of awareness during surgery (NICE, 2012). In cases where muscle relaxants are used, the risk of awareness is increased because signs of discomfort such as increased respiratory rate are masked by the temporary paralysis of skeletal muscles. Older patients and those with significant comorbidities are at an increased risk of awareness due to their potential for hemodynamic instability during surgery (Chhabra et al., 2016). Certain types of surgery, such as cardiac and trauma surgeries, carry an increased risk of awareness. Lastly, the use of a total intravenous anesthetic approach also warrants the use of a depth of anesthesia monitor (NICE, 2012).

Because IOA is such a catastrophic event, providers and administrators alike will benefit from reducing and preventing this phenomenon. This both increases patient safety and avoids any potential legal and financial implications resultant of an episode of awareness. Preventing IOA will increase patient safety and improve quality of care.

It should be noted that DoA monitoring has not been made a standard of care for the provision of anesthesia, because no level of performance has been established for the monitors, and because there is no direct means of measuring consciousness (Musizza & Ribaric, 2010). Because the monitors do not directly identify a measurable vital sign with clear parameters, such as heart rate, the technology has been slow to be adopted as a "gold standard" of measurement, especially with the different brands that govern the proprietary algorithms of depth of anesthesia monitoring (Musizza & Ribaric, 2010). Though no clear reason for this decision is explained, a common complaint heard about DoA monitors is cost. Data is lacking on comparison of costs related to depth of anesthesia monitors. Some studies have evaluated the BIS monitor for cost effectiveness, but not all compare this to the amount of money saved if there is an episode of unintended awareness. A study by Abenstein et al. (2009) explained that the cost of the monitoring electrodes is approximately seventeen dollars, and the cost of the monitors, which require replacement every seven years, is nine thousand dollars. Using the incidence of recall found by several other widely accepted studies on intraoperative recall, Abenstein (2009) concluded that the cost of avoiding recall with a BIS monitor costs $11,294-$25,814 per case. If DoA monitoring was used only in high-risk patients, Abenstein (2009) concluded that the amount saved per avoided incidence of intraoperative awareness would be $4,410.

A meta-analysis by Shepherd et al. (2013) compares the cost of treating posttraumatic stress disorder related to an incident of intraoperative awareness. It was determined that after the costs were assessed for treating posttraumatic stress disorder for up to 12 years following the event, the cost-effectiveness of DoA monitoring (specifically the BIS monitor) is dependent on patient outcomes, and that for general surgical patients, the cost of monitoring is somewhat absorbed by the reduction of anesthetic drugs used. Avoiding posttraumatic stress disorder, though important, did not offer any financial incentives for avoidance because awareness is so rarely encountered.

Local Problem

Anesthesia providers do not consistently use depth of anesthesia monitors. In one study, researchers found that DoA monitoring was used in 53.54% of cases (Gelfand et al., 2017). Gelfand et al. (2017) also reported that no formal recommendations exist for when to use a DoA monitor—further proving that the guideline is not widely known. The guideline was first adopted in the United Kingdom in 2012, and later adopted in the United States by the Agency for Healthcare Research and Quality by the National Guidelines Clearinghouse (National Institute for Health and Care Excellence [NICE], 2012). Providers, who make IOA prevention a priority in their care, know common risk factors for IOA but awareness of the problem has not led to an increase in the rate of DoA monitor use (Gelfand et al., 2017).

At Banner University Medical Center in Tucson, Arizona, depth of anesthesia monitoring is available, but not regularly used by anesthesia providers. Further assessment of this site and needs will be conducted in as the project progresses.

Purpose

The purpose of this project was to determine what barriers, if any, were present that prevent providers from choosing to use a depth of anesthesia monitor as a regular part of their practice. Ultimately, it was the goal of this project to assess the needs of the providers involved, and to encourage the use of depth of anesthesia monitoring where appropriate, thereby improving quality of patient care. This occurred through an educational module and surveys that determined providers' experience with the monitors and their likelihood of using them. The educational module informed anesthesia providers about the guideline for use of DoA monitors. Relevant stakeholders to this project included anesthesia providers and hospital administrators. Anesthesia providers are especially important as stakeholders because they are directly responsible for monitoring, assessing, and treating the patient during the perioperative period, and are the providers directly responsible for whether the patient experiences IOA.

Study Question

What are some driving forces that would lead anesthesia providers to adopt a new status quo that would include the use of depth of anesthesia monitors in their practice of anesthesia? What are some restraining forces preventing this action, and what can be done to mediate them?

THEORETICAL FRAMEWORK AND SYNTHESIS OF EVIDENCE

Theoretical Framework

Theories are a set of concepts, or abstract ideas, that are observed or measured (Christenbery, 2011). Theories often address patient and provider concerns and help shape interventions for change. This project will examine what information drives providers to use or exclude a DoA monitor from their practice. The goal of this project is to encourage the use of DoA monitors by educating providers about the current clinical practice guideline which

recommends their use. Because encouraging greater use of DoA monitors is considered a change to practice, one of the best theories to guide this is Lewin's change theory.

Lewin's theory is a conceptual framework applied to understand change within a system, first described in 1947. Lewin describes planned changes as reaching a new level, with the intent being that the change becomes permanent (Lewin, 1947). Lewin discusses force fields, stating that for a change to take place and become secure, a force field must be in place that secures against further change (Lewin, 1947). This theory recognizes that change is a constant factor of life, stemming from the balance of driving and opposing forces. These forces progress through three stages: unfreezing, moving, and freezing at the new level (Lewin, 1947). Unfreezing is the process of assessing needs and preparing people involved to move from their current state to an improved level of practice (Ash, Miller, & Zaccagnini, 2017). This stage is the most significant to this project. Unfreezing will require providers to let go of their current opinions of DoA monitors and be willing to learn how they can be beneficial in their practice.

The movement phase occurs when the driving forces behind the change begin to motivate adoption by the members involved in the change. During the movement phase, restraining forces oppose the change, but these forces diminish as the change progresses. For the change to occur and reach completion, the driving forces must outweigh the opposing forces. This shifts the change forward in the intended direction. The movement phase is beyond the scope of this project, but if utilized, it would involve discussion between opposing views, coupled with evidence, to cause a shift in the viewpoints of anesthesia providers.

The last phase, freezing, (or refreezing as described by Lewin in the original document) refers to the securement of the change, which maintains the change as it becomes the new

standard (Lewin, 1947; Ash, Miller, & Zaccagnini, 2017). This too is beyond the scope of this project, but in a quality improvement project regarding DoA monitors, this stage would be the step where anesthesia providers have transitioned to using the monitors regularly and willingly.

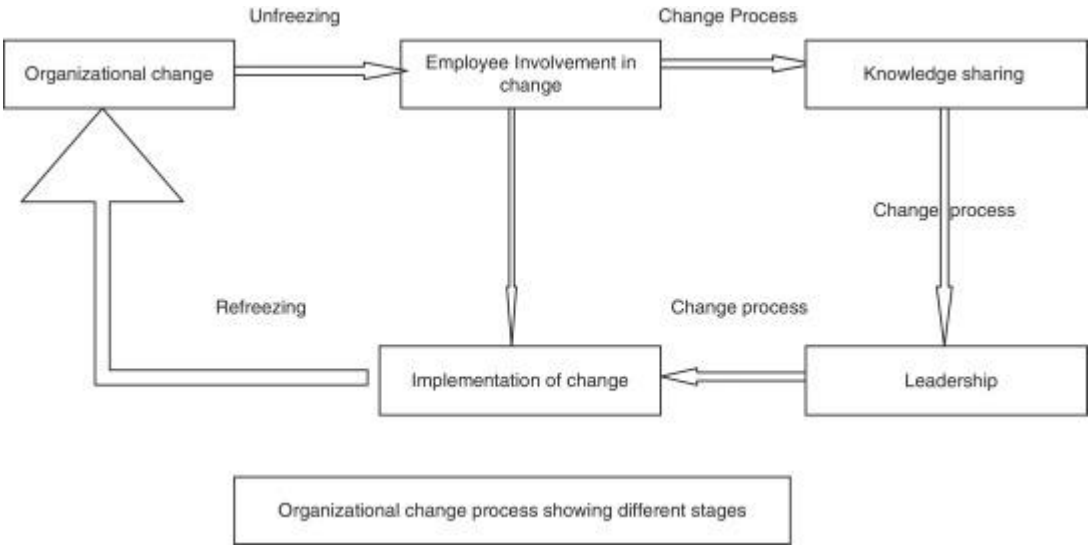

Figure 1. Lewin's Change Theory. Reprinted from "Kurt Lewin's change model: A critical review of the role of leadership and employee involvement in organizational change," by S.T. Hussain, S. Lei, T. Akram, M.J. Haider, S.H. Hussain, M. Ali, 2018, *Journal of Innovation and Knowledge, 3*, p. 126.

A concept that requires definition in the context of this project is depth of anesthesia monitors themselves. These monitors, though they will not provide any information for the statistical analysis of the project, will be the main topic of discussion.

Synthesis of Evidence

The purpose of this synthesis of literature is to explore the state of the science regarding the decision to use DoA monitoring. For tabular description of the studies included in this synthesis of evidence and findings see Appendix A. Search terms used to find these articles included "depth of anesthesia monitor," "bispectral index monitoring," and "entropy monitor,"

which is a term specific to the monitoring of anesthesia. The search filter used was “English & humans.” For the search term “depth of anesthesia monitor,” 739 results were obtained. For “bispectral index monitoring,” 1127 results were obtained. For “entropy monitoring,” 500 results were obtained. Year of publication was not a filter because older data regarding depth of anesthesia monitoring remains relevant as there has been some reported dispute of evidence and all studies regarding depth of anesthesia monitoring are relevant. Several of the articles chosen for the review are large, multi-center randomized control trials, which have been cited a number of times when evaluating depth of anesthesia monitoring, so it seemed fitting to include these trials. Ten articles are reviewed in the synthesis of evidence based on relevancy to this project.

Strengths

Strengths of evidence for using depth of anesthesia monitors include many factors related to patient safety, cost effectiveness, and overall improved quality of care. Strengths found throughout the studies, though not corroborated by all, were decreased use of anesthetic, decreased time in recovery, and decreased levels of intraoperative awareness.

One of the largest studies conducted regarding depth of anesthesia monitoring was the B-Aware trial, published in 2004, which established depth of anesthesia monitoring as an important tool in the practice of anesthesia. This study found that by using a depth of anesthesia monitor, the risk of awareness was reduced by 82% (Myles, Leslie, McNeil, Forbes, & Chan, 2004).

A review by Chhabra et al. (2016) demonstrated that there is moderate quality evidence to support decreased time to awakening, decreased recall of intraoperative awareness, and a reduction of inhalational anesthetic use when depth of anesthesia monitors are used. The review also found low quality evidence to support a reduction in intravenous anesthetic agent use (e.g.,

Propofol), and a decreased time to readiness to leave the post-anesthesia care unit (Chhabra et al., 2016). These results mirrored those of an earlier study by Jiahai et al. (2012) who found that versus standard monitoring, the use of a depth of anesthesia monitor both decreased the amount of time to tracheal extubation as well as the total amount of intravenous anesthetic agent used. Tewari, Bhadoria, Wadhawan, Prasad, and Kohli (2015), reported similar findings in a study indicating a reduction in overall intravenous anesthetic, but increased administration of pain medication. A randomized control trial by Lim et al. (2017) found that by using a depth of anesthesia monitor to confirm the presence of a deep hypnotic state, rocuronium-induced withdrawal movements in children decreased. Thus, using a depth of anesthesia monitor increased the safety of care and overall quality of care provided to these patients.

A study of provider practice patterns revealed that patient-specific factors are highly dependent on whether the provider uses a depth of anesthesia monitor during the surgical procedure (Gelfand et al., 2017). This study also reported that 53.54% of patients received Bispectral index (BIS) monitoring, interpreted as either a strength or a weakness. Greater than 50% of patients received DoA monitoring, but improvement is needed. Given the amount of information available about DoA monitoring, this value should be higher, and allows for a targeted improvement to take place. Gelfand et al. (2017) identified patient-specific factors that seemed to indicate an increased use of depth of anesthesia monitoring: increased age, greater ASA physical status, and extremes of body mass index (BMI). A strength is that the factors identified in the study were also identified by the clinical practice guideline's recommendation that suggests depth of anesthesia monitoring for these patients (Chhabra et al., 2016). The study was conducted independently of the clinical practice guideline but found that providers who do

use DoA monitoring have identified, on their own, patients who are more at risk of intraoperative awareness and have chosen to use a DoA monitor while providing their anesthesia. A systematic review by Shepherd et al. (2013) indicated that the most cost-effective form of depth of anesthesia monitoring is the Bispectral index (BIS) monitor.

Weaknesses

Weaknesses related to DoA monitoring are related to inconsistencies found among studies. The B-Unaware trial found that there was no association between depth of anesthesia monitoring and the incidence of awareness. The authors reported that awareness still occurred, even when the depth of anesthesia index value remained within the recommended range to prevent awareness (Avidan et al., 2008). Another weakness was discovered during the BAG-RECALL study of 2011. Results showed that when compared to end-tidal anesthetic concentration, depth of anesthesia monitoring via a Bispectral index monitor was not superior. End-tidal anesthetic concentration is the percentage of anesthetic gas exhaled by the patient. This percentage is compared to the minimum alveolar concentration (MAC), which is defined as the amount of anesthetic gas needed to produce immobility in 50% of patients (Brown et al. 2015). This is expressed in terms of percentages of ‘1’ atmosphere—so at “1 MAC,” 50% of patients are unable to move their head or extremities purposefully (Kossick, 2014). End-tidal anesthetic concentration is the gold standard for dosing volatile anesthetics and keeping the patient at a level of 0.7-1.3 MAC is reported to prevent intraoperative awareness (Brown et al. 2015).

In the BAG-RECALL study, patients who received end-tidal anesthetic concentration monitoring have less incidence of awareness than did the patients assigned to the depth of anesthesia group (Avidan et al., 2011). This study was not without limitations—one of the most

important being that the data was viewed as one method against the other. It did not consider the possibility of combining methods to use together in the prevention of awareness. Both groups had patients who reported intraoperative awareness, and though this was a higher number in the depth of anesthesia monitoring group, it does not mean that depth of anesthesia monitoring is useless.

A small study by Zetterlund et al. (2016) was also unable to corroborate the results of the B-Aware study, and found that when correlating BIS to EEG, there was no significant relationship. This study was limited by a small sample size of only 35 participants.

A major limitation of depth of anesthesia monitoring is that it is intended to prevent intraoperative awareness, a phenomenon that is extremely rare—by some reports as low as 0.1% (Gelb, Leslie, Stanski, & Shafer, 2010), making it a difficult topic to study.

Conflicting information regarding cost-effectiveness has added increased skepticism to the use of DoA monitors. As mentioned, for each incidence of prevented awareness, the cost per prevention in a high-risk patient is $4,410 (Abenstein, 2009). Cost is highly variable among different brands of DoA monitors. For example, Shepherd et al. (2013) reported that the cost of sensor strips for the BIS monitor was approximately 25 times costlier than the strips used for the Narcotrend monitor, but the Narcotrend monitor itself costs more than twice the cost of the BIS monitor.

Gaps in Literature

A significant gap in the literature is that there is only one study that examined the use of depth of anesthesia monitoring by providers (Gelfand et al., 2017). Though there is controversy and varying results of whether depth of anesthesia monitoring is effective, there are few studies

showing its usage rate by providers, and no studies that speak to the reasons providers choose whether to use a depth of anesthesia monitor. Most studies regarding depth of anesthesia monitoring relate to the monitors themselves, not the providers responsible for using them.

METHODS

The purpose of this project was to determine what barriers, if any, were present that prevent providers from choosing to use a depth of anesthesia monitor as a regular part of their practice. A post-evaluation, once the educational module was completed, determined whether providers planned to increase their use of depth of anesthesia monitoring.

Design

This project used a quality improvement design to assess providers' pre-existing knowledge, attitudes, and beliefs regarding their personal use of depth of anesthesia (DoA) monitors during the provision of anesthesia. The intended goal was to increase knowledge of DoA monitors and increase their use in anesthetic cases where such a monitor has been deemed appropriate by an existing clinical practice guideline.

The approach to this project was a quantitative descriptive design. Descriptive research observes, describes, and documents situations as they naturally occur (Polit & Beck, 2012), and in this project, the patterns and routines of anesthesia providers' use of DoA monitors were examined. To assess this information, a pre-test/post-test design was used.

The quality improvement model used for this project was the Model for Improvement which is recommended by the Institute for Healthcare Improvement and was developed in 2009 by Langley, Moen, Nolan, Norman and Provost (2009). This model helped inform and accelerate the potential quality improvement changes recommended by the results of this project. There are

two main parts to the Model for Improvement (Langley et al., 2009). The first part is a series of three fundamental questions that are asked when an improvement is needed. These questions are displayed in Figure 1. The second part of the Model for Improvement is a cycle, known as the Plan Do Study Act, or PDSA. Implementing change in this two-step fashion allows testing a change on a small scale, learning from it, and refining it for spread beyond the sample population (Langley et al., 2009).

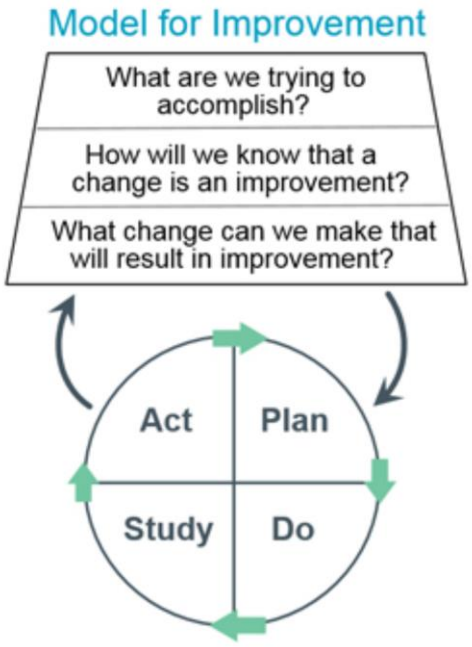

Figure 2. Model for Improvement. Reprinted from *The Improvement Guide: A Practical Approach to Enhancing Organizational Performance*, by G.L. Langley, R. Moen, K.M. Nolan, T.W. Nolan, C.L. Norman, and L.P. Provost, 2009, San Francisco: Jossey-Bass Publishers. Copyright 2009 by Jossey-Bass Publishers.

Approval for this project was obtained from the University of Arizona College of Nursing Departmental Review Committee. An evaluation by the Institutional Review Board (IRB) determined that the project does not require oversight by the University of Arizona (Appendices G, H, and I).

Setting

The setting for this project is Banner University Medical Center Tucson (BUMCT), a large hospital in Tucson, Arizona that is part of the Banner Health System. This setting was chosen because it is classified as a Level I trauma center which sees a variety of surgical procedures. It is the largest hospital in Tucson, with 487 patient beds. While not all facilities have invested in DoA monitors, BUMCT is a facility that does have DoA monitors available. Though DoA monitors are not available in every one of the twenty operating rooms, several portable monitors are available for use that are compatible with both the operating room monitors and the computerized charting system. This setting also has twenty-five Certified Registered Nurse Anesthetists (CRNAs) that would be available to participate by providing insight into their experience at the site with using DoA monitors.

Participants

All Certified Registered Nurse Anesthetists (CRNAs) working in this facility were invited to participate in this project. Anesthesiologists function in a supervisory role in this facility and thus excluded from the project. Though the addition of including resident physicians in the project would have added additional data and insight, it was determined that due to the learning structure of residency programs, residents do not practice anesthesia freely and therefore the choice to use the monitors is not necessarily a decision made of the resident's own volition. It was unclear upon initiating this project if any formal training was provided to CRNAs upon hiring in how to use the DoA monitors. CRNAs participating in this project are employees of the facility, no restrictions were placed related to part-time, full-time, or per diem employees.

CRNA participants for this project were recruited from the department using an email communication and invitation with a link to the pretest, posttest, and attached education module PowerPoint (See Appendices B, C, and D). A disclosure form was included in the body of the email and distributed by the anesthesia administrative assistant at the site (See Appendix F). Emailing done by the anesthesia administrative assistant was approved by the chief CRNA and chief anesthesiologist at the facility.

Intervention

The intervention was a PowerPoint education module, accessed at the providers' discretion through the invitation email. The module informed providers about the existing clinical practice guideline regarding depth of anesthesia monitoring and recommended types of surgeries and patients who should receive DoA monitoring per the guideline. The brief educational PowerPoint informed providers what the recommendations are for the use of the monitors. Specifically, the recommendation mentioned the types of surgeries, types of patients, and general risk factors for intraoperative awareness minimized by using a depth of anesthesia monitor. This also included a brief overview of the number scoring system for depth of anesthesia monitors and a literature review of the evidence supporting the use of depth of anesthesia monitoring. CRNAs had three days to complete the module from the time that the email was sent.

Tools

The pretest used for this project measured the existing knowledge of the participating providers and determined how frequently providers used DoA monitors. At this facility, the only available DoA monitor is the SEDline. The posttest determined how likely providers were to

implement the teaching into their practice in the future. These questions were asked via an electronic Qualtrics survey (Qualtrics, Provo, Utah, 2018). Questions provided on the pre and posttests included yes or no answers, a Likert-type rating scale, and open-ended questions to provide feedback on the module itself and its effectiveness. Demographic data collected included number of years the provider has been in practice (Appendix B).

Items of interest included the number of providers already using depth of anesthesia monitoring and those that state they will add it to their regular practice following the completion of the educational module. The questions asked assessed practice patterns of providers, and the facilitators and barriers to DoA monitor use. All questions were approved by the project committee as well as the Director of Professional Practice and the Non-research Data Use Committee at the facility of implementation.

Data Collection

Data was collected anonymously from the pre and posttests which participants were asked to complete before and after the education module. The pre and posttests were administered using Qualtrics web-based surveying (Qualtrics, Provo, Utah, 2018). This service was used without cost due to the license held by the University of Arizona. Using a web-based survey site helps avoid human error in transcribing data obtained from more traditional paper surveys and ensures that participants have been de-identified. The project committee members reviewed the pretest and posttest prior to implementation for face validity to make sure the questions are measuring the target construct (Polit & Beck, 2012). On average, the pretest, education module, and posttest took providers approximately 10 minutes to complete.

Data Analysis

Data was analyzed using Qualtrics, and then imported to Microsoft Excel for graphical and tabular display. Descriptive statistics compared results from the pretest to the results of the posttest. Ordinal measurement, which sorts participants based on attributes, (Polit & Beck, 2012) was used to observe relationships between number of years as a provider, whether the provider uses depth of anesthesia monitoring, and whether they intend to use it in the future. This way, individual providers' responses could be analyzed for whether they are currently using DoA monitors, and whether they will in the future. The open-ended questions asked of participants were evaluated using quantitative content analysis. Quantitative content analysis may be used as a form of testing and measurement to find trends and generalize data that is collected (Rourke & Anderson, 2004). This data was used to determine if the teaching was effective, and more broadly, to see if the use of DoA monitors will increase following the intervention. A final executive summary with recommendations will be shared with the site, Banner University Medical Center Tucson, to inform the anesthesia team if any changes have occurred and what the major barriers to DoA monitoring were found to be.

Resources

No funding was needed to implement this project. A necessary component was the approval of the site's quality improvement team prior to the project implementation.

Ethical Considerations

Respect for Persons

This project included anesthesia providers only—specifically CRNAs. Providers were invited to participate in the project, and the confidentiality of their responses was maintained.

Providers were informed that they may choose not to participate, or to withdraw their consent at any time during the project. Providers were encouraged to freely share their opinion, and all responses were kept confidential.

Beneficence

There were no direct risks to participants. This project seeks to improve the quality of care offered to perioperative patients, so it is the anticipation that through this project, patient care would indirectly improve. For assessment of the risks of this project and to ensure its safety, the Institutional Review Board confirmed that no human research standards apply. It is to the benefit of CRNAs to know what the recommendations are regarding depth of anesthesia monitoring.

Justice

This project targets a population of CRNAs with few items of exclusion criteria, therefore no injustice is imposed. Anesthesia providers were not required to participate, and they did not receive any benefit for participating, or any punishment for non-participation The CRNAs participating in the study can be considered a vulnerable population, with influence from authoritative personnel swaying the decision to participate in the project. To avoid any abuse of vulnerable populations, and to make clear that there is no punishment nor reward for participating in the module, the invitation to participate was sent out by the anesthesia program coordinator, not by any person of authority.

Dissemination

Following the completion of the project, the results were reported to the Director of Professional Practice at Banner University Medical Center Tucson, as well as the chief CRNA of

the facility. The aggregate findings of this study can be used to evaluate the frequency of depth of anesthesia monitoring use at the facility and can be used to determine what providers need in order to increase their use of DoA monitoring, should the facility wish to continue providing this technology.

RESULTS

Findings

Of the twenty-five CRNAs that the distribution email reached, seven CRNAs completed the study within the three days allotted for data collection. This is a response rate of 28 percent. The time it took to complete the pretest, module, and posttest ranged from 5.2 minutes to 13.7 minutes. Years of experience as a CRNA was well-represented by the study population, as displayed in Table 1. There were two participants with over ten years of experience, and two participants with less than one year of experience. It should be noted that when the pretest questions were transcribed to the Qualtrics survey, one option was eliminated accidentally from the survey response options. There should have been an option for 3-6 years of experience as a CRNA, but this option was omitted. The data presented is transcribed exactly as it was entered by participants into the Qualtrics survey, despite the omission error.

TABLE 1. *Participant demographics.*

Years as a CRNA	Number of Participants
Less than 1 year	2
1-3 years	1
6-10 years	2
More than 10 years	2
Total	7

Of the seven CRNAs who completed the education module and surveys, only two had ever used a depth of anesthesia monitor while working at the facility (29%), and only one had used the monitor within the last month (14%). Furthermore, this participant indicated that he/she had only used the monitor 1-5 times within that month. No relationship could be made between the years of experience as a provider and the likeliness of using a DoA monitor. When asked how likely they were to use a DoA monitor as part of their regular anesthesia practice, none of the participants responded that they were likely to use such a device. Figure 3 below shows the response frequency to likeliness of using a DoA monitor.

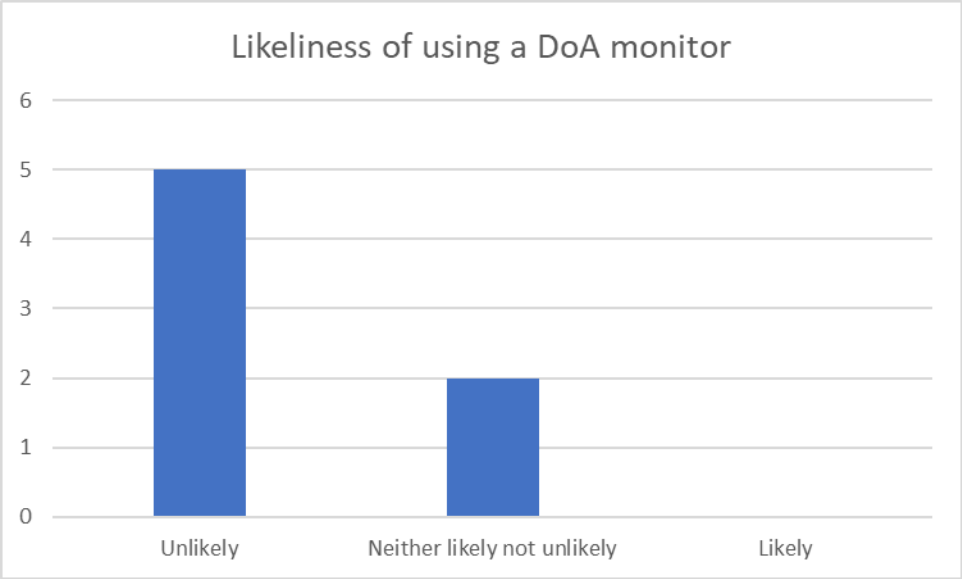

FIGURE 3. Likeliness of using a DoA monitor.

After viewing the educational module, 100% of participants (N=7) reported that they would be willing to try using the SEDline DoA monitor if they had not used it already.

When asked during the pretest if they felt DoA monitoring was a useful tool in their practice, 42% (N=3) of participants agreed, 42% (N=3) of participants disagreed, and 14% could neither agree nor disagree (N=1).

In response to the statement “I feel comfortable using and interpreting the values obtained from a SEDline monitor in my practice,” 67% of providers agreed (N=4). When asked again on the posttest about their comfort level with using the monitors, 100% (N=7) of participants then reported that they felt comfortable using and interpreting the values obtained by the monitor.

Question 6 of the pretest stated, “I know which types of procedures and which types of patients have been recommended to receive depth of anesthesia monitoring with a SEDline or similar device,” to which 71% (N=5) agreed. On the posttest this question was asked again, and 100% (N=7) of respondents reported that they now agreed with this statement.

In response to a select-all type question from the pretest regarding when DoA monitoring is recommended, the responses were as follows in Figure 4. It should be noted that according to the NICE (2012), all of these risk factors are serious enough to warrant the use of a DoA monitor while administering a general anesthetic. The respondents all selected the risk factor of “history of prior awareness under general anesthesia” as a reason to use a DoA monitor, however, none of them recognized that using a DoA monitor while providing anesthesia to a patient with a history of having a difficult airway is another recommendation of the NICE (2012).

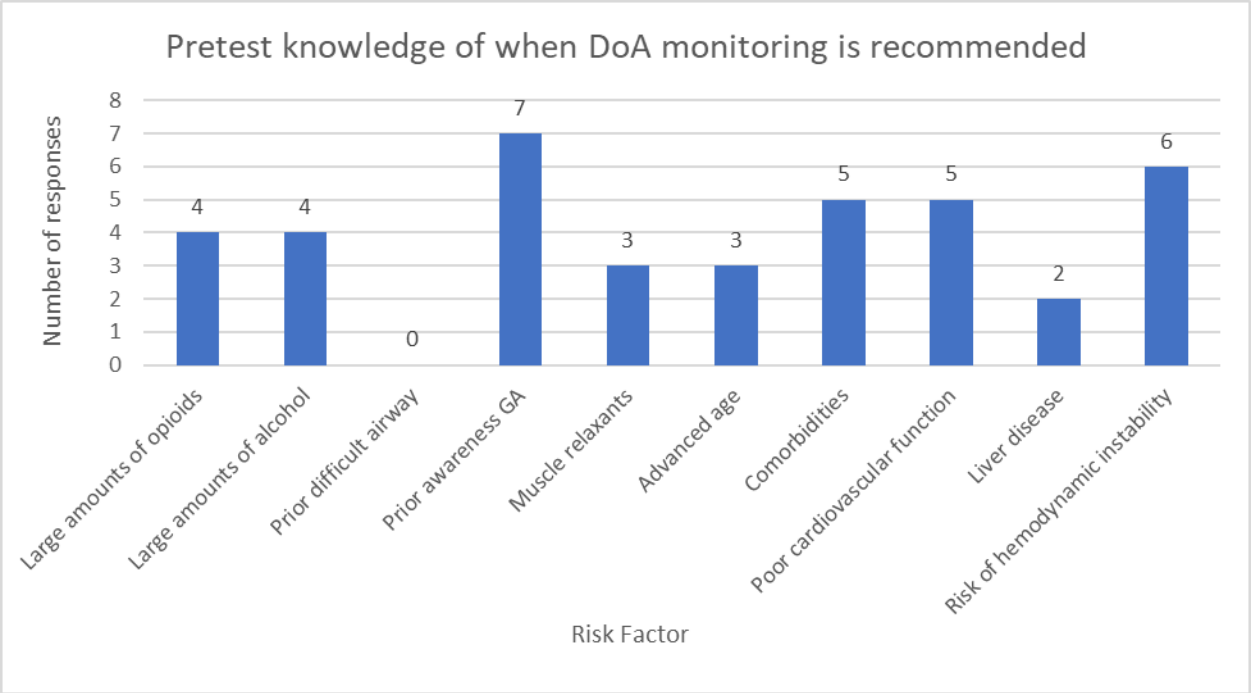

FIGURE 4. Pretest knowledge of when DoA monitoring is recommended.

The final question of the pretest asked, "if you answered that you are not extremely likely to use a SEDline monitor, please select reasons why, choosing all that apply. A write-in option is available as well." Figure 5 addresses the responses obtained to this question, and Table 2 displays the free-text responses. Fifty-seven percent of respondents (N=4), reported that they prefer using a different approach to their practice, such as monitoring the end-tidal anesthetic concentration.

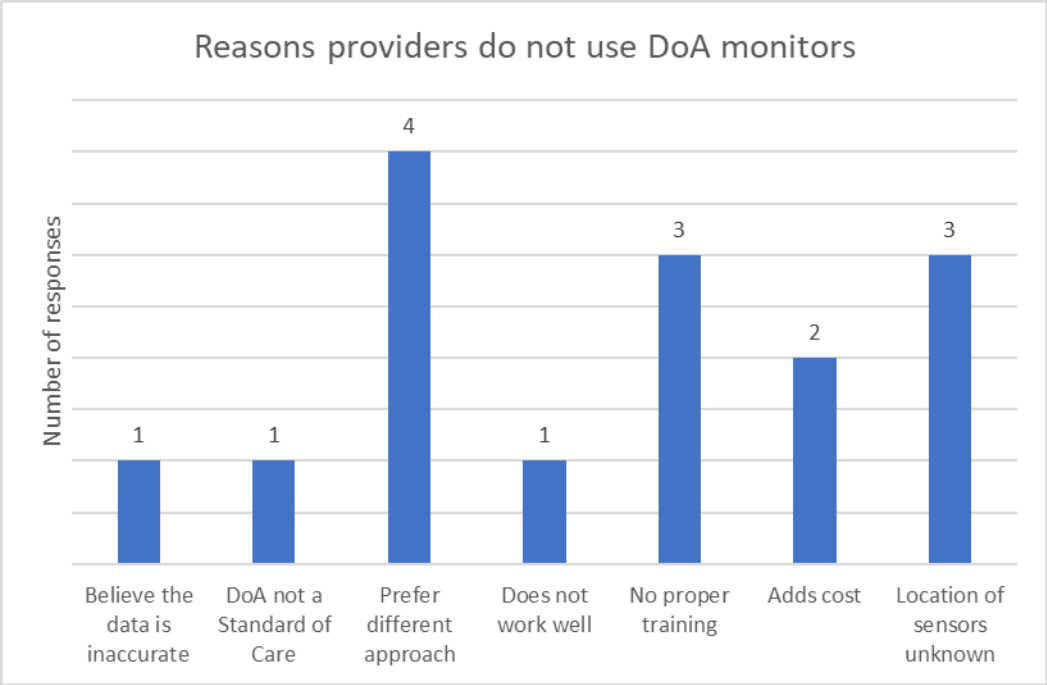

FIGURE 5. Reasons providers do not use DoA monitors.

TABLE 2. *Free text responses to why providers are not likely to use a DoA monitor.*

Don't know that facility has such a monitor
I would reserve use for patients at risk of awareness
Often feel like I'm treating the Sedline monitor and not the patient. More comfortable treating the clinical picture not a number from a monitor.

After viewing the educational module, 100% of respondents (N=7) reported that they would be willing to try using the SEDline depth of anesthesia monitor if they had not already used it. In addition, all respondents reported that they found the educational content clear and useful, and one respondent gave the feedback of "Good PowerPoint, very informative."

In response to the question "what would enhance your ability to use the monitors or make you more confident in your use and interpretation of the monitors' values?", providers were offered a multiple-response question. Figure 6 displays the number of responses per item,

displaying that most providers (N=5, or 71% of respondents) feel that they would improve their ability and confidence to use DoA monitoring if some sort of an in-service were offered to staff. A write-in option was available as well but was not filled out by any of the participants.

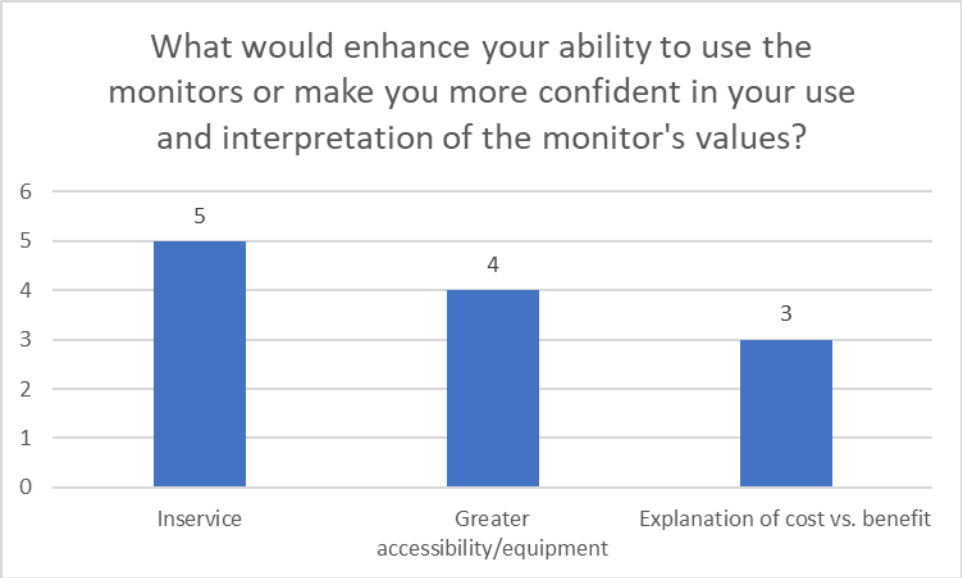

FIGURE 6. What would enhance your ability to use the monitors or make you more confident in your use and interpretation of the monitor's values?

When asked if their opinions of the SEDline DoA monitor had changed after completing the module, only two respondents reported that their opinions had changed. Not enough information was gathered from the short write-in question responses that would allow for any reasonable content analysis.

During data analysis it became evident that some inconsistencies existed between the pretest and posttest questions. Questions were similarly worded but should have been doubled checked for consistency. For example, question 7 of the pretest reads "I know which types of procedures and which types of patients have been recommended to receive depth of anesthesia monitoring with a SEDline or similar device," and question 4 of the posttest reads "I know which

types of procedures and which types of patients have been recommended to receive depth of anesthesia monitoring." Though the questions ask the same information, consistency of wording was needed.

Another opportunity for improvement includes options of multiple response questions. For example, one question asked. "If you answered that you are not extremely likely to use a SEDline monitor, please select reasons why, choosing all that apply." The answer selections offered included one that read "I prefer a different approach (End-tidal anesthetic concentration, etc.)." This response leaves too much information open to interpretation. Participants should have been required to identify their preferred approach to monitoring the depth of anesthetic. Using "etcetera" in the response does not allow for the specific information that should have been obtained throughout the course of the study.

DISCUSSION

Through the course of this project, several barriers to DoA monitoring were assessed and confirmed by the participants of the educational module. These barriers include lack of training with the device, the need for greater accessibility to equipment, and a poor understanding of the cost versus benefit of using such a device. In healthcare, when a technology is new, it is very costly. Since the monitors have now been on the market for many years, informing providers of the cost of using the monitors, as well as which party is responsible for this cost, could help providers in deciding to use the monitors more frequently. Healthcare costs are often paid by the patient, the patient's insurance, or are assumed by the hospital, and a solid understanding of who is paying for DoA monitoring could aid providers in making the decision to add regular DoA monitoring to their practice. One participant expressed concern that using the monitors may

diminish the care provided to the patient—because the number from the monitor is dictating treatment, not the patient's overall clinical picture.

Limitations

There were several limitations encountered during this study. The first was the transcribing error mentioned in the results section—that several years of provider experience were omitted from the options available for selection by participants of the education module and survey. Three days for data collection is also a limitation as potential participants may only view their emails from a work computer, thus missing the available timing of the survey if it did not align with their scheduled work days. Another limitation is small sample size. A response rate of 28% is not indicative of the practice of all other CRNAs working at the facility.

Recommendations

A majority of CRNAs surveyed selected the choice of an in-service to enhance their ability to use the monitors or make them more confident in the use and interpretation of the monitor's values. One recommendation is to schedule an in-service for providers regarding their use. The company that owns the SEDline device would provide this as a service for the continued use of their product. Providing an in-service with detailed information about how to read the monitors' data and apply its use to practice would help CRNAs at this facility gain confidence in their use of the monitors and use them more frequently, as reported by the participants of this study.

Conclusion

Lack of training and unfamiliarity with the storage location of SEDline monitors contributed to decreased use of DoA monitoring by CRNAs. Providers responded that after viewing the educational module, they felt somewhat more confident in using and interpreting the

DoA monitors and the data obtained from them, but still responded that an in-service on the use of the device would be helpful in increasing their comfort level and encourage more frequent use of the monitors.

This was a worthwhile study for this setting, as the initial impression from this facility is that the DoA monitors are rarely used. A quality improvement approach was appropriate for this project as the DoA monitors can lead to an increase in patient safety. For future inquiry into DoA monitors at this facility, the Model for Improvement should be used and a PDSA cycle performed. After this initial cycle, changes could be made for improvement, and the next PDSA cycle would commence.

APPENDIX A:

SYNTHESIS OF EVIDENCE

Synthesis of Evidence

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Avidan, M. S., Jacobsohn, E., Glick, D., Burnside, B. A., Zhang, L., Villafranca, A., . . . Mashour, G. A. (2011). Prevention of intraoperative awareness in a high-risk surgical population. *The New England Journal of Medicine, 365*(7), 591-600. (The BAG-RECALL Study)	Key Variables: • Definite intraoperative awareness Hypothesis: A protocol incorporating the electroencephalogram-derived BIS is superior to a protocol incorporating standard monitoring of end-tidal anesthetic-agent concentration (ETAC) for the prevention of awareness	Not defined	Randomized control trial	6041 patients considered to be at high risk for awareness Total included in the trial: 5809 Study took place from May 2008 through May 2010 BIS protocol group, n=2861 ETAC protocol group, n=2852	BIS Quatro (Covidien) sensor Electronic recording of anesthesia data using Medivision software (iMDsoft) Data were transferred to Microsoft Excel or TrendFace Solo software (ixellence) Brice questionnaire	BIS group awareness incidence was 0.24% ETAC group awareness incidence 0.07% There was no difference in amount of anesthesia administered between groups BIS superiority was not supported
Avidan, M. S., Zhang, L., Burnside, B. A., Finkel, K. J., Searleman, A. C., Aelvidge, J. A., . . . Jacobsohn, E. (2008). Anesthesia awareness and the bispectral index. *New England Journal of Medicine, 358*, 1097-1108. doi:10.1056/NEJMoa0707361 (B-Unaware Trial)	Key variables: • Awareness • BIS value Objective: to determine whether the incidence of anesthesia awareness is reduced in high-risk patients when clinicians follow a BIS-guided protocol rather than an ETAG-guided protocol.	Not defined	Randomized control trial	2000 patients, randomly assigned to receive BIS-guided anesthesia or end-tidal anesthetic gas (ETAG)-guided anesthesia BIS-guided group, n=967 ETAG-guided group, n= 974	BIS monitor with BIS Quatro Sensor (Aspect Medical Systems) Brice questionnaire used to interview patients at 3 intervals to assess for awareness Statistical analysis completed with R statistical environment (R Foundation for Statistical Computing)	Overall incidence of definite awareness was 0.21% Overall incidence of definite or possible awareness was 0.46% BIS use did not result in lower incidence of awareness BIS use did not reduce the amount of volatile anesthetic gas used

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Caputo, T. D., Ramsay, M. A., Rossman, J. A., Beach, M. M., Griffiths, G. R., Meyrat, B., . . . Ezzo, P. (2011). Evaluation of the SEDline to improve the safety and efficiency of conscious sedation. *Baylor University Medical Center Proceedings, 24*(3), 200-204.	Key Variables: • Satisfaction • Amnesia • Patient state index (PSI) • Ramsey sedation scale (RSS) • Medications administered • Adverse events • Electroencephalography • Patients perspectives	Not defined	Case controlled study	21 outpatient periodontics patients receiving conscious sedation with midazolam and fentanyl Age: at least 18 years Sedation administered before local anesthetic to desired effect. Signs of sedation defined as: Verrill's sign (ptosis), slurred speech, and feelings of warmth or relaxation	SEDline monitor, applied before sedation, PSI recorded at 5-minute intervals Patients were surveyed using a modified Iowa Satisfaction with Sedation Survey (ISSS) and visual analogue scales for pain, amnesia, and satisfaction	Poor correlation between PSI and RSS values Patient satisfaction correlated with amnesia (P=0.012) Pain correlated with amnesia (P=0.006) Results limited by high electromyogram (EMG) activity which affected PSI scores High EMG activity and higher PSI values may give the impression that the patient is undersedated, and thus lead to oversedation
Chhabra, A., Subramaniam, R., Srivastava, A., Prabhakar, H., Kalaivani, M., & Paranjape, S. (2016). Spectral entropy monitoring for adults and children undergoing general anesthesia. *Cochrane Reviews*(3), 1-66. doi:10.1002/14651858.	Key Variables: • Time to awakening • Recall of intraoperative awareness • Inhalational anesthetic use • Intravenous anesthetic use • Time to readiness to leave the post-anesthesia care unit	Not defined	Intervention Review	Included RCTs conducted in adults and children older than 2 years Studies selected included those that compared entropy monitoring to standard practice Studies selected also included those that	Search methods included searches of Cochrane Central Register of Controlled Trials, MEDLINE via Ovis SP, and EMBASE via Ovid SP Studies included were reviewed independently by two review authors	Moderate quality evidence was found to support: • Time to awakening • Recall of intraoperative awareness • Reduction of inhalational anesthetic use Low quality evidence was found to support:

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
CD010135.pub2 (Clinical Practice Guideline)	Objective: Assess the effectiveness of entropy monitoring in facilitating faster recovery from general anesthesia Secondary objective: assess the effectiveness of entropy monitoring in preventing postoperative recall of intraoperative events (awareness) following general anesthesia			utilized BIS monitoring to assess anesthetic depth 11 RCTs		• Reduction in intravenous anesthetic agent use • Time to readiness to leave the post-anesthesia care unit
Gelfand, M. E., Gabriel, R. A., Gimlich, R., Beutler, S. S., & Urman, R. D. (2017). Practice patterns in the intraoperative use of bispectral index monitoring. *Journal of Clinical Monitoring and Computing, 31*, 281-289. doi:10.1007/s10877-016-9845-5	Key Variables: • Age group • Sex • Body mass index (BMI) • American Society of Anesthesiologists (ASA) Physical Status • Anesthesia provider type (anesthesiologist, CRNA, resident physician) • Use of inhaled anesthetics vs. total intravenous anesthesia (TIVA)	Not defined	Retrospective chart review	55,210 retrospectively reviewed surgical cases. Dates: January 2013 through October 2014 Setting: Brigham and Women's Hospital, a 779-bed, tertiary care academic medical center in Boston, MA.	R Project for Statistical Computing MetaVision intraoperative electronic record system	53.54% of all patients received BIS monitoring Mean age of patients receiving BIS monitoring: 59.69 Patient specific factors: increased age, greater ASA physical status, extremes of BMI Procedure related factors: long-acting paralytic agent, TIVA, use of an endotracheal tube, emergency case, longer length of case, and surgical service

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
	• Type of surgery • Use of BIS monitor to measure depth of anesthesia					(cardiac, cardiology, vascular, thoracic, general, neurosurgery, oncology, transplant, orthopedic, and emergency surgery). Procedures where an anesthesia resident was present
Lim, B. G., Lee, I. O., Kim, Y. S., Won, Y. J., Kim, H., & Kong, M. H. (2017). The utility of bisectral index monitoring for prevention of rocuronium-induced withdrawal movement in children: A randomized controlled trial. *Medicine*, *96*(2), e5871. doi:doi: 10.1097/MD.0000000000005871	Key Variables: • Time at loss of eyelash reflex • Minimum BIS value after thiopental sodium injection • Time of rocuronium injection • BIS value 15 seconds after rocuronium injection • Heart rate variation % (HRV) • Withdrawal movement (WM) Hypothesis: Rocuronium-induced withdrawal movements	Not defined	Randomized control trial	156 children, ages 3-12 years, scheduled for minor elective surgery (n=135). All patients were identified as American Society of Anesthesiologists physical status of 1. Participants were 81 males, 54 females. Average age in group C was 7 years, in group T 8 years, and in group S 6 years. Group C: Control group, patients received 0.6 mg/kg rocuronium at the loss of eyelash reflex.	Aspect A-2000 BIS monitor (version XP, from Aspect Medical Systems, Newton, MA) with pediatric BIS sensor WM assessed as no movements; arm only; generalized response with more than one extremity but no requirement for restraint of the body; and generalized response requiring restraint of the body and that caused coughing or breath holding • Data analyzed using SPSS	Group C: Loss of eyelash reflex after thiopental sodium administration (TSA) was on average 29.6 seconds, with mean BIS of 85. The mean BIS value 15 seconds after rocuronium injection was 55.1. The HRV averaged 7.5%. Incidence of WM was 100%. Group T significant results: mean minimum BIS value after TSA, 32.0 ($p<0.05$). BIS value at rocuronium injection averaged 36.6 ($p<0.05$). Incidence of WM was 95.6% (not significant). Group S significant

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
	are a result of lack of anesthetic depth, and can be prevented by using a BIS-driven protocol to monitor deep hypnotic state during the induction of anesthesia			Group T: Rocuronium 0.6 mg/kg administered when bispectral index (BIS) level fell to less than 40. Group S: if the BIS did not fall to less than 40 after thiopental sodium, manual ventilation with 6 L/min oxygen and 8% sevoflurane gas was administered. Rocuronium 0.6 mg/kg was administered once the BIS fell to less than 40. Setting**:** Korea University Guro Hospital in Seoul, Republic of Korea.		results: mean minimum BIS value after TSA, 50.8 ($p<0.05$ when compared to both Group C and Group T). Time of rocuronium injection averaged 212.0 seconds ($p<0.05$ when compared to both Group C and Group T). BIS value at rocuronium injection averaged 37.0 ($p<0.05$). Incidence of WM was 80.0% ($p<0.05$). Deep hypnotic state as determined by BIS values < 40 was found to suppress WMs in pediatric patients.
Jiahai, M., Xueyan, W., Yonggang, X., Jianhong, Y., Qunhui, H., Zhi, L., . . . Xiuliang, J. (2012). Spectral Entropy Monitoring Reduces Anesthesic Dosage for	Key Variables: • Course of surgery (based on State Entropy and Response Entropy values) • Consumption of anesthetics	Not defined	Randomized control trial	70 patients undergoing off-pump coronary artery bypass graft (OPCAB). All were first-time OPCAB surgery recipients.	S/5 entropy module and entropy sensor (Datex-Ohmeda brand) Arterial blood samples to test ACTH levels Statistical analysis	Time to tracheal extubation in the entropy group was on average 312 minutes, in the control group 405 minutes ($p<0.05$) Cumulative doses of

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Patients Undergoing Off-Pump Coronary Artery Bypass Graft Surgery. *Journal of Cardiothoracic and Vascular Anesthesia, 26*(5), 818-821. doi:doi:10.1053/j.jvca.2012.01.028	• Intraoperative recall • Adrenocorticotropic hormone (ACTH) level • Cortisol level Objective: to test the feasibility of entropy monitoring during off-pump coronary artery bypass graft (OPCAB) and determine if it changed the dosage of anesthetics.			Control group (n=35) 20 males, 5 females Entropy group (n=35) 19 males, 6 females. Setting**:** Yantai Yuhuangding Hospital, a teaching hospital in Yantai, China.	with SPSS	Propofol per patient averaged 1085 mg in the entropy group, and 1536 mg in the control group ($p<0.05$) Cumulative doses of sufentanil per patient averaged 468 mcg in the entropy group, 624 mcg in the control group ($p<0.05$). Less anesthesia and less narcotic given to patients in the entropy group No patients reported intraoperative recall
Myles, P. S., Leslie, K., McNeil, J., Forbes, A., & Chan, M. T. (2004, May 29). Bispectral index monitoring to prevent awareness during anaesthesia: the B-Aware randomised controlled trial. *Lancet, 363*(9423), 1757-1763. (B-Aware Trial)	Key Variables: • Awareness Objective: to assess whether BIS monitoring decreases the incidence of awareness during surgeries using general anesthesia and muscle relaxants.	Not defined	Randomized controlled trial	Sample: Surgical patients, age 18 or older, with at least one risk factor for awareness (caesarean section, high-risk cardiac surgery, acute trauma with hypovolemia, rigid bronchoscopy, significant impairment of cardiovascular status and expected	BIS monitor (version 3.4, Aspect Medical Systems, Newton, MA)	In the BIS group, there were 22 reports of confirmed/possible awareness, 2 reports of definite awareness In the routine care group, there were 27 reports of confirmed/possible awareness, 11 confirmed as definite awareness BIS-guided anesthesia reduced rates of awareness by 82% in

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
				intraoperative hypotension, severe end-stage lung disease, past history of awareness, expected difficult intubation, heavy alcohol intake, chronic benzodiazepine or opioid use, or current protease inhibitor therapy). 2463 patients, 1225 in the BIS group and 1238 in the routine care group		patients considered "at-risk" for awareness
Shepherd, J., Jones, J., Frampton, G. K., Bryant, J., Baxter, L., & Cooper, K. (2013). Clinical effectiveness and cost-effectiveness of depth of anaesthesia monitoring (E-Entropy, Bispectral Index and Narcotrend): a systematic review and economic evaluation. *Health Technology Assessment, 17*(34).	Key Variables: • Quality-adjusted life-year (QALY) Objective: to assess the clinical and cost-effectiveness of the following technologies: BIS, E-Entropy, and Narcotrend	Not defined	Systematic review	22 RCTs comparing BIS, E-Entropy, and Narcotrend with standard clinical monitoring RCTs found using MEDLINE, EMBASE, the Cochrane Library, and the Health Technology Assessment database	6 trials were combined in a fixed-effect meta-analysis	Evidence supporting reduction in intraoperative awareness was limited Depth of anesthesia monitors reduced general anesthetic consumption and anesthesia recovery time Cost effectiveness appears dependent on many factors, including the probability of awareness on a patient-

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						by-patient basis
Tewari, S., Bhadoria, P., Wadhawan, S., Prasad, S., & Kohli, A. (2016). Entropy vs standard clinical monitoring using total intravenous anesthesia during transvaginal oocyte retrieval in patients for in vitro fertilization. *Journal of Clinical Anesthesia, 34*, 105-112. doi:http://dx.doi.org/10.1016/j.jclinane.2016.02.029	Key Variables: • Total Propofol consumption (TP) • Total fentanyl consumption (TF) • On-table recovery time (T1) • Time to discharge (T2) • Rescue analgesia and antiemesis in the PACU • Intraoperative awareness (A) Objective: Minimize drug use in outpatient surgery, while minimizing the risks of intraoperative awareness and pain.	Not defined	Prospective randomized control study	127 female patients, American Society of Anesthesiologists class I and II, presenting for transvaginal oocyte retrieval (TVOR). All patients received total intravenous anesthesia (TIVA) with Propofol and fentanyl. (n=120). In both groups the mean duration of surgery was 36.7 minutes. Setting: Operating theater and postoperative recovery unit (PACU) at an unnamed in vitro fertilization center in New Delhi, India.	S/5 Entropy monitor (GE Healthcare) Response entropy (RE) State entropy (SE) Statistical analysis with SPSS	6.7% less Propofol was given when entropy monitoring was used, (p=0.01) Patients with entropy monitors received 10.9% more fentanyl, (p=0.007) T1 was less in group EM, by almost 1 minute (p=0.009). Mean T2 in group CM was 37.00 minutes, and in group EM 34.16 minutes, (p=0.26). In group CM, 28.3% of patients required rescue analgesia, while 10% of patients in group EM required rescue analgesia, (p=0.01). In group CM, 26.7% of patients required rescue antiemesis in the PACU, compared to 18.3% in group EM. This was not statistically significant, (p=0.274). No intraoperative awareness was reported

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						in either group.
Zetterlund, E.-L., Green, H., Oscarsson, A., Vikingsson, S., Vrethem, M., Lindholm, M.-L., & Eintrei, C. (2016). Determination of loss of consciousness: a comparison of clinical assessment, bispectral index and electroencephlogram: An observational study. *European Journal of Anaesthesiology, 33*(12), 922-928. doi:10.1097/EJA.0000000000000532	Key variables: • BIS • EEG • Clinical LOC Objective: evaluate the ability of BIS monitoring to assess changes in the level of unconsciousness and consciousness in patients receiving total intravenous anesthesia with Propofol.	Not defined	Observational cohort study	41 American Society of Anesthesiologists class I patients. Age range 18-49. (n=35). BMI values 20-30. Patients were undergoing same-day surgery under general anesthesia, provided as TIVA, with Propofol and remifentanil. 43% of patients were men. Mean age 33 years, mean BMI 24 Setting: University Hospital Linköping, University Hospital Örebro, Finspång Hospital, and Kalmar Hospital in Sweden from October 2011 to April 2013.	BIS monitor (Aspect Medical Systems) EEG recordings (Nicolet One Neurodiagnostic system) which were later interpreted by a neurophysiologist Blood samples—analyzing the plasma concentrations of Propofol Statistical analysis obtained using Statistica software and Microsoft Excel	54% of patients had BIS values less than 40 at clinical LOC, ranging from 16 to 50, with a median of 38. At baseline, median BIS value was 97. At clinical LOC, 3% of patients were at EEG stage 2, 43% were at EEG stage 3, 37% were at stage 4, and 17% were at EEG stage 5. When correlating BIS to EEG, no significant relationship was found ($p=0.064$). Limited by small study size.

APPENDIX B:

PRE-TEST

Pretest

Please answer all questions to the best of your ability, reflecting on your current practice within this facility. Any and all responses are helpful in determining attitudes and beliefs toward depth of anesthesia monitoring as well as barriers toward its use. The information provided will remain confidential and will be used only for study purposes. There are no right or wrong answers. Thank you for participating!

1. For how many total years have you practiced anesthesia?

   <1 year 1-3 years 3-6 years 6-10 years >10 years >20 years

2. I have used a depth of anesthesia monitor (SEDline) at this facility.

   Yes No

3. How likely are you to use a depth of anesthesia monitor (SEDline) on an "average" case?

   1=Extremely Unlikely 2=Somewhat Unlikely 3=Neither likely nor unlikely 4=Somewhat likely 5=Extremely Likely

4. Thinking back to the last month of your anesthesia practice, during approximately how many anesthetics did you use the SEDline depth of anesthesia monitor?

   0 1-5 5-10 10-20 Greater than 20

5. I find depth of anesthesia monitoring with a SEDline or other device a useful tool in my practice:

   1=Strongly Disagree 2=Somewhat disagree 3=Neither agree nor disagree 4=Somewhat agree 5=Strongly Agree

6. I feel comfortable using and interpreting the values obtained from a SEDline monitor in my practice:

1=Strongly Disagree 2=Somewhat disagree 3=Neither agree nor disagree 4=Somewhat agree 5=Strongly Agree

7. I know which types of procedures and which types of patients have been recommended to receive depth of anesthesia monitoring with a SEDline or similar device.

   1=Strongly Disagree 2=Somewhat disagree 3=Neither agree nor disagree 4=Somewhat agree 5=Strongly Agree

8. Which of the following patient conditions are serious enough to receive depth of anesthesia monitoring? Select all that apply.

   Use of large amounts of opioids

   Use of large amounts of alcohol

   History of a difficult airway

   History of prior awareness under general anesthesia

   Use of muscle relaxants

   Advanced age

   Significant comorbidities

   Poor cardiovascular function

   Liver disease

   Types of surgery where there is greater risk of hemodynamic instability

9. If you answered that you are not extremely likely to use a SEDline monitor, please select reasons why, choosing all that apply. A write-in option is available as well.

   I believe the data to be inaccurate

   Monitoring the depth of anesthesia is not a Standard of Care

I prefer a different approach (End-tidal anesthetic concentration, etc.)

The SEDline monitor does not work well

I have not been trained how to properly use the SEDline monitor

Using the SEDline monitor adds an expensive cost for the hospital

I do not know where the SEDline sensor strips are stored

Other: _____

APPENDIX C:

POST-TEST

Posttest

Please answer all questions to the best of your ability, reflecting on your current practice within this facility. Any and all responses are helpful in determining attitudes and beliefs toward depth of anesthesia monitoring as well as barriers toward its use. The information provided will remain confidential and will be used only for study purposes. There are no right or wrong answers. Thank you for participating!

1. After viewing the educational module, would you be willing to try using the SEDline depth of anesthesia monitor, if you have not already?

   Yes No

2. I feel more confident about when to use a depth of anesthesia monitor after viewing the educational module.

   1=Strongly Disagree 2=Somewhat disagree 3=Neither agree nor disagree 4=Somewhat agree 5=Strongly Agree

3. I feel comfortable using and interpreting the values obtained from a SEDline depth of anesthesia monitor.

   1=Strongly Disagree 2=Somewhat disagree 3=Neither agree nor disagree 4=Somewhat agree 5=Strongly Agree

4. I know which types of procedures and which types of patients have been recommended to receive depth of anesthesia monitoring

   1=Strongly Disagree 2=Somewhat disagree 3=Neither agree nor disagree 4=Somewhat agree 5=Strongly Agree

5. Did the education module help prepare you to change your use of depth of anesthesia monitors?

   Yes No

6. Has your opinion of depth of anesthesia monitors changed?

   Yes No

7. What would enhance your ability to use the monitors or make you more confident in your use and interpretation of the monitor's values?

   An in-service on the device, including application of the monitor, and interpretation of the obtained values

   Greater accessibility to the necessary equipment

   An explanation of the cost vs. benefit of the monitors

   Other: _____

8. Was the educational content clear? Did you find the content useful?

   Yes No

9. Do you have any suggestions for improvement of the educational content?

APPENDIX D:

EDUCATION MODULE POWERPOINT SLIDES

Depth of Anesthesia Monitoring Recommendations

Sarah Zakula, BSN, RN

THE UNIVERSITY OF ARIZONA College of Nursing

1

Results of individual studies

- A study by Jiahai et al. (2012) reported that patients who received depth of anesthesia monitoring intraoperatively experienced faster times to extubation, fewer amounts of the intravenous anesthetic Propofol, and fewer amounts of narcotics.
- The "B-Aware" Trial conducted by Myles et al. (2004) found that depth of anesthesia monitoring reduced the rate of intraoperative awareness by 82% in patients considered to be "at-risk" for awareness

2

Support for using Depth of Anesthesia monitors in practice

- A review of multiple studies related to Depth of Anesthesia monitors found that with monitoring, patients experienced:
  - Shorter time to awakening following anesthesia
  - Less recall of intraoperative awareness
  - A reduction of inhalational anesthetic use
- This review was used to form a guideline for the use of depth of anesthesia monitors, which will be presented in this module

(Chhabra, 2016)

3

Other Findings

The BAG-RECALL Study (Avidan et al., 2011)

- There was no difference in amount of anesthesia administered when comparing DoA-guided anesthesia to end-tidal anesthetic concentration-guided anesthesia

Shepherd et al. (2013)

- Limited evidence supporting reduced awareness
- Cost-effectiveness dependent on many factors, such as patient's *probability* of awareness
- DoA monitoring reduced general anesthetic consumption and reduced anesthesia recovery time

4

Depth of Anesthesia Monitoring is recommended for the following scenarios/types of patients

During general anesthesia in patients at higher risk for **adverse outcomes**

- What are adverse outcomes related to depth of anesthesia?
  - **Unintended awareness**
  - **Excessively deep anesthesia**

(National Institute for Health and Care Excellence [NICE], 2012)

5

Depth of Anesthesia Monitoring is recommended for the following scenarios/types of patients (continued)

- High risk of **unintended awareness**
  - High opioid use
  - High alcohol use
  - History of difficult airway
  - History of prior awareness
  - Advanced age
  - Comorbidities
  - Certain types of surgery—greater risk of hemodynamic instability leading to lower anesthetic use

(National Institute for Health and Care Excellence [NICE], 2012)

6

Depth of Anesthesia Monitoring is recommended for the following scenarios/types of patients (continued)

- High risk for excessively deep anesthesia
  - Advanced age
  - Liver disease
  - High body mass (BMI)
  - Poor cardiovascular function

(National Institute for Health and Care Excellence [NICE], 2012)

7

Depth of Anesthesia Monitoring is recommended for the following scenarios/types of patients (continued)

- Total intravenous anesthesia (TIVA)
  - Depth of anesthesia monitoring is recommended because it is cost effective and end-tidal anesthetic concentration cannot be monitored
  - TIVA does NOT increase adverse outcomes when compared to inhaled anesthesia

National Institute for Health and Care Excellence [NICE], 2012)

8

Depth of Anesthesia Monitoring is recommended for the following scenarios/types of patients (continued)

- In addition, anesthesia providers should have appropriate training and experience with these monitors and understand the potential limitations of their use in clinical practice

(National Institute for Health and Care Excellence [NICE], 2012)

9

Fast facts about the SEDline Depth of Anesthesia Monitor

- The number obtained by the monitor is called the PSI—patient state index
- PSI uses a proprietary algorithm which considers:
  - The changes in power of EEG frequency bands
  - Changes in symmetry and synchronization between brain regions
  - Inhibition of regions in the frontal cortex

(Masimo, 2018)

10

Fast facts about the SEDline Depth of Anesthesia Monitor (continued)

- For application of the sensor, prep the forehead by cleaning with an alcohol swab, and when applying, do not press directly on the electrodes as the connecting gel may leak out
- The PSI values range from 0-100
  - 100 indicates a fully awake patient
  - The range of 25-50 indicates an optimal hypnotic state for general anesthesia
  - 0 is a fully suppressed EEG

(Masimo, 2018 and Ortega, 2007)

11

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APPENDIX E:

SITE AUTHORIZATION LETTER

Banner University Medical Center
Tucson

Date: March 7, 2019

To: Sarah Zakula, RN

cc: Mary Patricia Davis, PhD, RN

From: Jill Arzouman, DNP, RN

Re: Improving perioperative patient care using depth of anesthesia monitoring—a process improvement project

Our team at Banner University Medical Center Tucson has assessed your project proposal for implementation potential. From our review we have determined that the project is feasible and congruent with Banner Health initiatives. It aligns with our goal to “courageously innovate” by challenging the status quo of current practice.

Please follow the Banner Health "DNP Student Project Approval Process" that I previously sent to you. In accordance with that process you will need to submit this letter of support to the University of Arizona IRB. Because this is a nursing project, there is no need for a secondary sign off by medical providers. Following U of AZ determination of non-research, your proposal will be forwarded to the Banner Non-Research Determination Utilization Committee (NRDUC). This team provides one final check for HIPPA compliance.

Your next steps will include:

- Sending me the U of A IRB determination letter confirming non -research and
- Sending me the NRDUC approval letter

At that point in time I will generate a letter authorizing you to begin your project. Please do not hesitate to contact me for any questions during the process. Upon completion of your project, we request that you disseminate your findings to our Nursing Research/EBP committee or in another mutually agreed upon forum. Best wishes on the successful completion of your project.

Sincerely,

Jill Arzouman, DNP, RN, ACNS, BC, CMSRN
Director of Professional Practice, BUMCT/S & Clinics

APPENDIX F:

PARTICIPANT RECRUITMENT AND DISCLOSURE LETTER

Participant Recruitment and Disclosure Letter

Dear Providers,

My name is Sarah Zakula, BSN, RN. I am a Certified Registered Nurse Anesthetist Student at the University of Arizona, pursuing a degree as a Doctor of Nursing Practice (DNP). I am conducting a quality improvement project on provider's perceptions of depth of anesthesia monitors and the patterns of use of these monitors in your practice.

Participation in this DNP project involves completing a confidential online pre-test about your use of depth of anesthesia monitors and your perceptions of the technology. It also includes an educational module regarding depth of anesthesia monitoring, and a post-test to see if your intentions for use of the technology have changed after viewing the educational piece. The entire pre-test, module, and post-test will take approximately 20-30 minutes to complete, and will consist of demographic data as well as multiple choice and open-ended questions. You will have three days to complete the survey. After conclusion of the study, recommendations for improvement will be developed based on the aggregated results and shared with you at a staff meeting in the upcoming months.

Responses from this survey will remain confidential and will be used solely for the purpose of this study. Participation in this study is voluntary, and you may withdraw participation at any time without penalty. There are no foreseeable risks identified in the participation of this quality improvement project. Submission of the pre-test and post-test indicate that you are consenting to participation in this project. Participation or non-participation in this project will have no effect on your current or future employment status at Banner Health.

This quality improvement project was reviewed by the University of Arizona Institutional Review Board and has been deemed acceptable in meeting the requirements intended to protect the rights and wellbeing of its participants.

From the Banner Human Subjects Protection Program: completion of the survey and participation in this research project is voluntary. If you complete the survey you are confirming that you voluntarily consent to participate in this research project and you understand that participation in this project is not a condition of employment at Banner Health. You may complete this survey at work. If you elect to complete the survey on your own time, you will not be paid for your time spent on completing the survey.

Survey link: Qualtrics link

Should you have any questions or concerns, please contact Sarah Zakula at sarahz@email.arizona.edu.

Thank you for your time and consideration.

Respectfully,

Sarah Zakula, DNP Candidate

APPENDIX G:

THE UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL LETTER

THE UNIVERSITY OF ARIZONA
Research, Discovery & Innovation

Human Subjects Protection Program

1618 E. Helen St.
P.O.Box 245137
Tucson, AZ 85724-5137
Tel: (520) 626-6721
http://rgw.arizona.edu/compliance/home

Date:	April 02, 2019
Principal Investigator:	Sarah Ashley Zakula
Protocol Number:	1903471209
Protocol Title:	Improving Perioperative Patient Care Through Depth of Anesthesia Monitoring
Determination:	Human Subjects Review not Required

Documents Reviewed Concurrently:

Regulatory Determinations/Comments:

- Not Human Subjects Research as defined by 45 CFR 46.102(e): as presented, the activities described above do not meet the definition of research involving human subjects as cited in the regulations issued by the U.S. Department of Health and Human Services which state that "Human subject means a living individual about whom an investigator (whether professional or student)conducting research: (i) Obtains information or biospecimens through intervention or interaction with the individual, and uses, studies, or analyzes the information or biospecimens; or (ii) Obtains, uses, studies, analyzes, or generates identifiable private information or identifiable biospecimens. "

The project listed above does not require oversight by the University of Arizona.

If the nature of the project changes, submit a new determination form to the Human Subjects Protection Program (HSPP) for reassessment. Changes include addition of research with children, specimen collection, participant observation, prospective collection of data when the study was previously retrospective in nature, and broadening the scope or nature of the study activity. Please contact the HSPP to consult on whether the proposed changes need further review.

The University of Arizona maintains a Federalwide Assurance with the Office for Human Research Protections (FWA #00004218).

APPENDIX H:

BANNER HEALTH NON-RESEARCH DATA USE COMMITTEE (NRDUC) APPROVAL LETTER

Banner Health

April 8, 2019

Sarah Zakula

RE: NRDUC Project:
Protocol Number: 1903471209: Improving Perioperative Patient Care Through Depth of Anesthesia Monitoring
New Project UA Determination of Human Research Application Version Aug 2018; forwarded to Non-Research Data Use Committee on 4/2/2019
Non-Research Data Use Committee Evaluation: Approved on 4/8/2019

Dear Sarah Zakula,

Thank you for your submission of the UA Determination of Human Research Form which outlined the above noted project. On 4/2/19 UA IRB concluded that this project was not research and subsequently forwarded it to the Banner Health Non-Research Data Use Committee (NRDUC) for oversight and review. The project information you provided was reviewed and subsequently approved on April 8, 2019 by the BH NRDUC. Should you have any questions or concerns please feel free to reach out to the NRDUC chair at any time.
A copy of this letter will be placed in the NRDUC project file.

PLEASE NOTE
The NRDUC determination is based on the information you provided to the committee on your application version Aug 2018 and supporting documents forwarded to the NRDUC on 4/2/2019. If the project is modified in any way, including re-analysis of data, the determination is no longer valid. You must resubmit the project to the NRDUC for review and approval.
Please note: As part of continuing process improvement, random audits could be conducted to assess compliance and adherence with submitted/approved applications.
FYI - to be a considered a "quality improvement" activity under HIPAA, information needs to be provided back to Banner for quality/performance improvement purposes. Please make sure you work with the appropriate Banner internal owner or applicable Banner committee to share results.

Sincerely,

Kristen Eversole, BS, RHIA, CHPC
Banner Health Privacy Sr. Director/Privacy Officer, NRDUC Chair

APPENDIX I:

SITE AUTHORIZATION TO BEGIN DATA COLLECTION

Banner University Medicine

Date: April 12, 2019

To: Sarah Zakula, BSN, RN

Cc: Mary Patricia Davis, PhD, RN

From: Jill Arzouman, DNP, RN, ACNS, BC, CMSRN

Re: Improving Perioperative Patient Care Through Depth of Anesthesia Monitoring

==========

Thank you for submitting the required documentation from the University of Arizona IRB and Banner Non-Research Data Use Committee. As per our previous discussion, our Banner team has assessed your project proposal for implementation potential and appropriateness of the project within BUMCT. From my final review I have determined that the project is feasible and congruent with Banner Health initiatives.

You may now begin your project. Please do not hesitate to contact me for any questions during the process. I look forward to you presenting your results when the project is complete in a mutually agreed upon forum.

Best wishes on the successful completion of your project.

Sincerely,

Jill
Jill Arzouman
Director of Professional Practice
BUMCT/S & Clinics

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